

1 **What is claimed is:**

2 1. A method for forming a bottle-shaped trench,
3 comprising:

4 providing a semiconductor substrate with a trench
5 having a pad stack layer thereon;

6 filling a mask layer into the lower portion of the
7 trench;

8 using plasma nitridation to form a sidewall nitride
9 layer on the trench sidewall;

10 removing the mask layer; and

11 etching the lower portion of the trench to form a
12 bottle-shaped trench.

1 2. The method as claimed in claim 1, wherein the
2 pad stack layer comprises an oxide layer and a nitride
3 layer.

1 3. The method as claimed in claim 1, wherein the
2 mask layer is a photoresist material.

1 4. The method as claimed in claim 1, wherein the
2 plasma nitridation temperature is 25~100°C.

1 5. The method as claimed in claim 1, wherein the
2 lower portion of the trench is etched by wet etching.

1 6. The method as claimed in claim 5, wherein the
2 wet etching solution is ammonia ($\text{NH}_4\text{OH} + \text{H}_2\text{O}$).

1 7. The method as claimed in claim 1, wherein the
2 plasma nitridation pressure is 30~50Pa.

1 8. The method as claimed in claim 1, wherein the
2 plasma is RF plasma.

1 9. The method as claimed in claim 8, wherein the
2 RF power is 500~1000W.

1 10. A method for forming a bottle-shaped trench,
2 comprising:
3 providing a semiconductor substrate with a trench
4 having a pad stack layer thereon;
5 filling a photoresist layer into the lower portion
6 of the trench;
7 using 25~100°C plasma nitridation to form a sidewall
8 nitride layer on the pad stack layer and the
9 trench sidewall;
10 removing the photoresist layer; and
11 etching the lower portion of the trench to form a
12 bottle-shaped trench.

1 11. The method as claimed in claim 10, wherein the
2 lower portion of the trench etching is wet etching.

1 12. The method as claimed in claim 11, wherein the
2 wet etching solution is ammonia ($\text{NH}_4\text{OH} + \text{H}_2\text{O}$).

1 13. The method as claimed in claim 10, wherein the
2 plasma nitridation press is 30~50Pa.

1 14. The method as claimed in claim 10, wherein the
2 plasma is RF plasma.

1 15. The method as claimed in claim 14, wherein
2 the RF power is 500~1000W.

1 16. A method for forming a bottle-shaped trench,
2 comprising:
3 providing a semiconductor substrate with a trench
4 having a pad oxide layer and a nitride layer
5 thereon;
6 filling a mask layer into the lower portion of the
7 trench;
8 etching a portion of the pad oxide layer near the
9 trench to reveal a corner of the substrate;
10 using plasma nitridation to form a sidewall nitride
11 layer on the trench sidewall and to fill the
12 pad oxide recess;
13 removing the mask layer; and
14 etching the lower portion of the trench to form a
15 bottle-shaped trench.

1 17. The method as claimed in claim 16, wherein the
2 mask layer is photoresist.

1 18. The method as claimed in claim 16, wherein the
2 plasma nitridation temperature is 25~100°C.

1 19. The method as claimed in claim 16, wherein the
2 lower portion of the trench is etched by wet etching.

1 20. The method as claimed in claim 19, wherein the
2 wet etching solution is ammonia ($\text{NH}_4\text{OH} + \text{H}_2\text{O}$).

1 21. The method as claimed in claim 16, wherein the
2 plasma nitridation press is 30~50Pa.

1 22. The method as claimed in claim 16, wherein the
2 plasma is RF plasma.

1 23. The method as claimed in claim 22, wherein the
2 RF power is 500~1000W.

1 24. A method for forming a bottle-shaped trench,
2 comprising:
3 providing a semiconductor substrate with a trench
4 having a pad oxide layer and a nitride layer
5 thereon;
6 filling a photoresist layer into the lower portion
7 of the trench;
8 etching a portion of the pad oxide layer near the
9 trench to reveal a corner of the substrate;
10 using the 25~100°C plasma nitridation to form a
11 sidewall nitride layer on the trench sidewall
12 and to fill the pad oxide recess;
13 removing the photoresist layer; and
14 etching the lower portion of the trench to form a
15 bottle-shaped trench.

1 25. The method as claimed in claim 24, wherein the
2 lower portion of the trench is etched by wet etching.

1 26. The method as claimed in claim 25, wherein the
2 wet etching solution is ammonia ($\text{NH}_4\text{OH} + \text{H}_2\text{O}$).

1 27. The method as claimed in claim 24, wherein the
2 plasma nitridation pressure is 30~50Pa.

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1 28. The method as claimed in claim 24, wherein the
2 plasma is RF plasma.

1 29. The method as claimed in claim 28, wherein the
2 RF power is 500~1000W.